strength of confined concrete. See page 3, lines 17-19. The specification further describes that "an important consideration is to keep the Poisson's ratio of the tube less than concrete to provide the confinement to concrete. This increased strength depends on the fiber architecture and the thickness of the tube." See page 3, lines 20-23. Still further, the specification provides a further discussion of the relationship between the Poisson's ratio of the tubular housing and confinement of the filler material on page 6, lines 3-11. In particular, the specification describes that "to provide the confinement of the filler material 14, the Poisson's ratio of the tubular housing 12 is kept less than the filler material 14, which is particularly important for lateral confinement by the tube in the absence of pre-stressing. This increased strength depends on the fiber architecture and the thickness of the tube 12. The fiber architecture is the direction of fiber and amount of fiber used to make the tube. This architecture influences properties of the tube such as Poisson's ratio, modulus of elasticity and strength of the tube." Applicant respectfully submits that those of ordinary skill in the art, particularly in view of the detailed descriptions in the present specification, would readily appreciate the specific relation between the Poisson's ratio of the tubular housing 12 to confinement of the filler material 14. For at least this reason, Applicant submits that the rejection is misplaced.

In the Response to Arguments section in paragraph 9 of the Office Action, the Office Action again evidences a clear misunderstanding of the engineering concepts associated with Poisson's ratio, providing that "Poisson's ratio is considered a matter of desired results rather than a specific structural limitation." As discussed in detail during the interview conducted July 16, 2002, Poisson's ratio itself is a <u>structural</u> characteristic

of a particular component. Applicant submits that those of ordinary skill in the art could readily modify parts of a particular component to affect its Poisson's ratio. For example, the present specification on page 6 describes a preferred exemplary embodiment of the invention, wherein the tubular housing 12 is formed of a fiber-reinforced polymer. As discussed previously, as would be apparent to those of ordinary skill in the art, in order to keep the Poisson's ratio of the tubular housing less than a filler material, increased strength of the tubular housing can be attained by adjusting the fiber architecture in the thickness of the tube.

The Examiner's contention that the "general public" could not meet this structural limitation is clearly wrong since as noted in the exemplary embodiment described in the specification, increased strength of the tubular housing can be obtained by adjusting the fiber architecture and the thickness of the tube. Still further, as should be readily understood by the Examiner, it is not the "general public" for which the enablement requirement of §112 pertains. Rather, 35 U.S.C. §112 provides that "the specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable <u>any person skilled in the art to which it pertains, or with which it is most nearly connected</u>, to make and use the same . . . ."

In light of the broad and well-known application of Poisson's ratio and further with reference to the specific discussion in the present specification, Applicant respectfully submits that this rejection is misplaced.

Reconsideration and withdrawal of the rejection are respectfully requested.

Claims 1 and 13 were rejected under 35 U.S.C. §102(b) over U.S. Patent No. 4,260,127 to Nakamura. This rejection is respectfully traversed.

Nakamura describes a yoke for use in construction work and particularly to clamp the side shutters in concrete work. At least end portions of the yoke are filled with foamed plastic 5. The foamed plastic serves to absorb noise produced by the bumping of the yoke against a hard object. Moreover, the plastic 5 serves to prevent concrete from flowing into the yoke.

As should be readily apparent, the yoke described in Nakamura would be completely unsuitable for use as a construction beam defined according to the present invention. The strength requirements would be wholly inadequate.

In an effort to clarify this important distinction, claim 1 has been amended to recite that the tubular housing and the solid material are formed of materials that effect a beam strength exceeding that of a correspondingly sized wood construction beam. Support for this recitation can be found in the specification at, for example, page 3, lines 9-13. Since at least this feature of the invention is lacking in Nakamura, Applicant submits that the rejection is misplaced.

Still further, Nakamura (and the Office Action, once again) is silent with respect to a relationship of the Poisson's ratio of the tubular housing and solid material filling the tubular housing as claimed. As noted previously, the structural configuration of the tube to effect the claimed Poisson's ratio differences was an important discovery for enabling the construction beam to function properly in the absence of pre-stressing. The Office Action still does not refer to a single teaching in the Nakamura patent with respect to the

claimed Poisson's ratio. For this reason also, Applicant submits that the rejection is misplaced.

With respect to dependent claim 13, Applicant submits that this claim is allowable at least by virtue of its dependency on an allowable independent claim.

Reconsideration and withdrawal of the rejection are respectfully requested.

In paragraphs 6 and 7 of the Office Action, claims 1-13 and 21 were rejected under 35 U.S.C. §103(a) over U.S. Patent No. 5,761,875 to Oliphant et al. in view of U.S. Patent No. 5,960,597 to Schwager and U.S. Patent No. 3,086,273 to Welborn, and claims 14-20 were rejected under 35 U.S.C. §103(a) over Oliphant in view of Welborn and Schwager. These rejections are respectfully traversed.

In the personal interview conducted on July 16, 2002, Applicant's representative pointed out many distinctions between the references of record and the claimed invention. This discussion is at least partially reflected in the Examiner's Interview Summary. In particular, the Examiner's Interview Summary provides that the "Examiner agreed the Oliphant prior art does not teach the tubular housing which filled with concrete or solid material . . . ." There is no discussion in the present Office Action concerning how the Oliphant patent in fact meets the features of the claimed invention, aside from the inaccurate contention that Oliphant discloses a reinforced concrete pole . . . "having a geometrically tubular housing 10 filled with a concrete material 32 . . . ." To the contrary, as discussed previously and during the personal interview, Oliphant describes a reinforced concrete pole provided with an attachment mechanism

for attachments to the pole. The concrete pole is generally conventional in construction and very certainly lacks the claimed tubular housing forming part of a construction beam.

Schwager describes a method for post-tensioning columns, wherein concrete columns are wound with an external cable to increase column performance for earthquake forces and the like. Schwager similarly lacks the claimed tubular housing of the construction beam. Moreover, the post-tensioning described in Schwager generally relates to post-tensioning the cable that is wrapped around the concrete column. Certainly, this structure is considerably distinct from that of the claimed invention.

Finally, Welborn describes a method for pre-stressing concrete, wherein post-tensioning tendons are coated with a concrete retardant to protect the tendons from bonding to the concrete so that after the concrete has cured, proper tensioning of the tendon can take place. See, for example, column 3, lines 31-73. Similar to Oliphant and Schwager, Welborn lacks the tubular housing forming part of the construction beam as claimed.

As also mentioned previously, none of Oliphant, Schwager and Welborn even remotely appreciates a relationship of the Poisson's ratio of the tubular housing and solid material filling the tubular housing as claimed. Rather, a Poisson's ratio relative to a solid filling material is not pertinent to their respective constructions.

With respect to dependent claims 2-13, Applicant submits that these claims are allowable at least by virtue of their dependency on an allowable independent claim. In addition, claim 7 recites that the tubular housing is formed by a fiber-reinforced polymer. Since the cited references lack the claimed tubular housing, this structure is also lacking

in the art of record. Further specifications for the tubular housing are set forth in claim 12.

With respect to claims 14-20, Oliphant is deficient in the context of these claims for reasons similar to those discussed above and apparently understood by the Examiner in the July 16, 2002 personal interview. (". . . Examiner agreed the Oliphant prior art does not teach the tubular housing which filled with concrete or solid material.").

Moreover, to the extent that claim 14 defines structure similar to that set forth in claim 1, Applicant respectfully submits that this rejection is misplaced for at least the reasons discussed above. Additionally, the construction beams formed of a tubular housing filled with the solid material and including the Poisson's ratio relationship as set forth in claim 14 enabled the construction of the claimed deck system including the construction beams secured side-to-side. Each of the references of record, in contrast, relates to a construction beam without any such tubular housing. It is well settled that "the mere fact that the prior art may be modified in the manner suggested by the examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Fritch*, 23 USPQ2d 1780 (Fed. Cir. 1992). Since the references of record generally relate to concrete structures without any such tubular housing, Applicant respectfully submits that the references lack even a remote suggestion and/or the desirability to either (1) include a tubular housing or (2) secure construction beams in a side-to-side relationship to construct a deck system. For at least this reason also, Applicant respectfully submits that the rejection is misplaced.

The Office Action further contends that it would have been obvious to provide at least one transverse aperture "to provide the interconnection between tubular concrete structures." Since none of the cited references provides any teaching or suggestion of constructing a deck system by securing construction beams of the present invention side-to-side, however, the references similarly lack any suggestion to interconnect such structures. Claim 16 further recites that at least one reinforcing bar is secured in the transverse channel under tension to provide a transverse post-stress in the deck system. This structure is similarly lacking in the references of record.

With respect to claim 17, as noted above, the references of record lack any teaching or suggestion of the claimed tubular housing as well as the claimed relationship of the Poisson's ratio of the tubular housing and solid material therein. The Office Action contends that "the using of a Poisson's formula [sic] to obtain the ratio of the tubular housing is less than the solid material, since it have been held that discovering and optimum value of a result effective variable involves only routine skill in the art." As noted, Oliphant, Welborn and Schwager, however, are silent with respect to any such Poisson's ratio of the materials used for constructing the concrete beams. Moreover, since the references of record lack the claimed tubular housing, a Poisson's ratio is irrelevant to their disclosed constructions. Indeed, although silent in each of the references, it is likely that the concrete beams are formed using conventional concrete beam forming methods.

Still further, although the Office Action recognizes that "Oliphant, Welborn and Schwager did not teach the deck system comprising a plurality of construction beams

secured side-to-side," the Office Action concludes that "it would have been obvious . . . to have more than one of the similar structures of form a deck [sic] and could be modified a Welborn's concrete tubular structure to have openings at the transverse reinforced rods." As support for this contention, the Office Action provides that "[t]he suggestion for doing so would have been to provide the interconnection between tubular concrete structures." Applicant submits, however, that the only suggestion to provide such "interconnection" is derived from the Applicant's own disclosure. As noted, Oliphant describes a reinforced concrete pole provided with an attachment mechanism for attachments to the pole. Schwager describes a method for post-tensioning columns, wherein concrete columns are wound with an external cable to increase column performance for earthquake forces and the like. Welborn describes a method for pre-stressing concrete, wherein post-tensioning tendons are coated with a concrete retardant to protect the tendons from bonding to the concrete so that after the concrete has cured, proper tensioning of the tendon can take place. Notwithstanding the missing structural features of the invention, none of these references, taken singly or in combination, provides any remote suggestion for securing concrete poles in a side-to-side configuration. For these reasons also, Applicant respectfully submits that the rejection is misplaced.

With respect to the remaining dependent claims, Applicant submits that these claims are allowable at least by virtue of their dependency on an allowable independent claim.

Reconsideration and withdrawal of the rejection are respectfully requested.

In view of the foregoing amendments and remarks, Applicant respectfully submits that the claims are patentable over the art of record and that the application is in condition for allowance. Should the Examiner believe that anything further is desirable in order to place the application in condition for allowance, the Examiner is invited to contact Applicant's undersigned attorney at the telephone number listed below.

Prompt passage to issuance is earnestly solicited.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version With Markings To Show Changes Made**."

Respectfully submitted,

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Attachments:

Pages 5-16 and 5-17 of *Marks' Standard Handbook for Mechanical Engineers*
Pages 39-40 of *Mechanical Engineering Design*, Shigley et al.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

1. (Twice Amended) A construction beam comprising a tubular housing filled with a solid material having a Poisson's ratio, wherein the tubular housing is constructed such that a Poisson's ratio of the tubular housing is less than the solid material to thereby confine the solid material, the tubular housing forming part of the construction beam, wherein the tubular housing and the solid material are formed of materials that effect a beam strength exceeding that of a correspondingly sized wood construction beam.

17. (Thrice Amended) A method of forming a construction beam comprising filling a tubular housing with a solid material having a Poisson's ratio, the tubular housing forming a part of the construction beam, wherein the tubular housing is constructed such that a Poisson's ratio of the tubular housing is less than the solid material to thereby confine the solid material, wherein the tubular housing and the solid material are formed of materials that effect a beam strength exceeding that of a correspondingly sized wood construction beam.

Marks' Standard Handbook for Mechanical Engineers

Revised by a staff of specialists

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MECHANICS OF MATERIALS

by J. P. Vidosic

REFERENCES: Timoshenko and MacCullough, "Elements of Strength of Materials," Van Nostrand. Seeley, "Advanced Mechanics of Materials," Wiley. Timoshenko and Goodier, "Theory of Elasticity," McGraw-Hill. Phillips, "Introduction to Plasticity," Ronald. Van Den Broek, "Theory of Limit Design," Wiley. Hetényi, "Handbook of Experimental Stress Analysis," Wiley. Dean and Douglas, "Semi-Conductor and Conventional Strain Gages," Academic. Robertson and Harvey, "The Engineering Uses of Holography," University Printing House, London. Sellers, "Basic Training Guide to the New Metrics and SI Units," National Tool, Die and Precision Machining Association.

Main Symbols

Unit Stress

S = apparent stress
S_v or S_s = pure shearing
T = true (ideal) stress
S_p = proportional elastic limit
S_y = yield point
S_M = ultimate strength, tension
S_c = ultimate compression
S_v = vertical shear in beams
S_R = modulus of rupture

Moment

M = bending
M_t = torsion

External Action

P = force
G = weight of body
W = weight of load
V = external shear

Modulus of Elasticity

E = longitudinal
G = shearing
K = bulk
U_p = modulus of resilience
U_R = ultimate resilience

Geometrical

l = length
A = area
V = volume
v = velocity
r = radius of gyration
I = rectangular moment of inertia
I_P or J = polar moment of inertia

Deformation

e = gross, longitudinal
s = unit, longitudinal
d or α = unit, angular
s' = unit, lateral
μ = Poisson's ratio
n = reciprocal of Poisson's ratio
r = radius
f = deflection

SIMPLE STRESSES AND STRAINS

Deformations are changes in form produced by external forces or loads that act on nonrigid bodies. Deformations are **longitudinal,** e, a lengthening (+) or shortening (−) of the body; and **angular,** d, a change of angle between the faces.

Unit deformation (dimensionless number) is the deformation in unit distance. Unit longitudinal deformation $s = e/l$ (Fig. 1). Unit angular-deformation tan α equals α approx (Fig. 2).

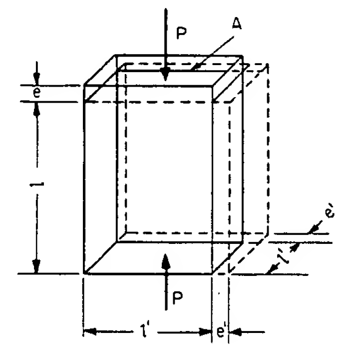

Fig. 1

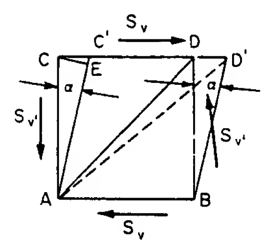

Fig. 2

Accompanying a longitudinal deformation e is a **lateral** deformation of e' (Fig. 1). The ratio of s'/s is **Poisson's ratio** μ. Values of μ are: glass, 0.244; brass, 0.333; copper, 0.333; cast iron, 0.270; wrought iron, 0.278; steel, 0.303; lead, 0.430; concrete, 0.10 to 0.20 at working stresses and 0.25 at higher stresses.

Stress is an internal distributed force; it is the internal mechanical reaction of the material accompanying deformation. Stresses always occur in pairs. Stresses are **normal**

[tensile stress (+) and compressive stress (−)]; and **tangential,** or **shearing.**

Intensity of stress, or **unit stress,** S, lb/in², (kgf/cm²) is the amount of force per unit of area (Fig. 3). P is the load acting through the center of gravity of the area. The uniformly distributed normal stress is

$$S = P/A$$

When the stress is not uniformly distributed, $S = dP/dA$.

A **long rod** will stretch under its own weight G and a terminal load P (see Fig. 4). The total elongation e is that due to the terminal load plus that due to one-half the weight of the rod considered as acting at the end.

$$e = [Pl + (Gl/2)]/AE$$

The maximum stress is at the upper end.

When a **load is carried by several paths** to a support, the different paths take portions of the load in proportion to their stiffness, which is controlled by material (E) and by design.

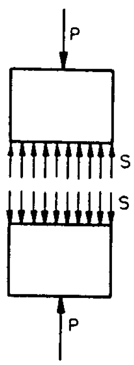

Fig. 3

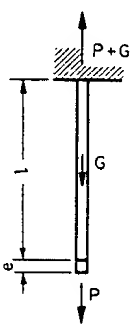

Fig. 4

EXAMPLE. Two pairs of bars rigidly connected (with the same elongation) carry a load P_0 (Fig. 5). A_1, A_2 and E_1, E_2 and P_1, P_2 and S_1, S_2 are cross sections, moduli of elasticity, loads, and stresses of the bars, respectively; e = elongation.

$$e = P_1l/(E_1A_1) = P_2l/(E_2A_2)$$
$$P_0 = 2P_1 + 2P_2$$
$$S_2 = P_2/A_2 = ½[P_0E_2/(E_1A_1 + E_2A_2)]$$
$$S_1 = ½[P_0E_1/(E_1A_1 + E_2A_2)]$$

Temperature Stresses When the deformation arising from change of temperature is prevented, temperature stresses arise that are proportional to the amount of deformation that is prevented. Let a = coefficient of expansion per degree of temperature, l_1 = length of bar at temperature t_1, and l_2 = length at temperature t_2. Then

$$l_2 = l_1[1 + a(t_2 - t_1)]$$

If, subsequently, the bar is cooled to a temperature t_1, the proportionate deformation is $s = a(t_2 - t_1)$ and the corresponding unit stress $S = Ea \times (t_2 - t_1)$. For **coefficients of expansion,** see Sec. 4. In the case of steel, a change of temperature of 12°F (6.7 K, 6.7°C) will cause in general a unit stress of 2,340 lb/in² (164 kgf/cm²).

Shearing stresses (Fig. 2) act tangentially to surface of contact and do not change length of sides of elementary volume; they

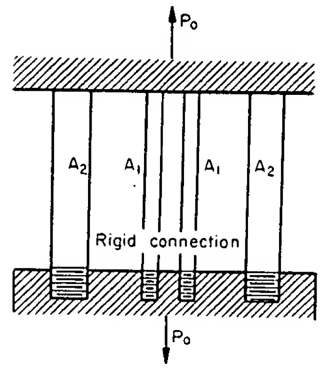

Fig. 5

change the angle between faces and the **length of diagonal.** Two pairs of shearing stresses must act together. **Shearing stress intensities are of equal magnitude on all four faces of an element.** $S_v = S_v'$ (Fig. 6).

In the presence of **pure shear** on external faces (Fig. 6), the **resultant stress** S on one diagonal plane at 45° is pure tension and on the other diagonal plane pure compression; $S = S_v = S_v'$. S on diagonal plane is called "diagonal tension" by writers on reinforced concrete. Failure under pure shear is difficult to produce experimentally, except under torsion and in certain special cases. Figure 7 shows an ideal case, and Fig. 8 a common form of test piece that introduces bending stresses.

Let Fig. 9 represent the section of area A on which a

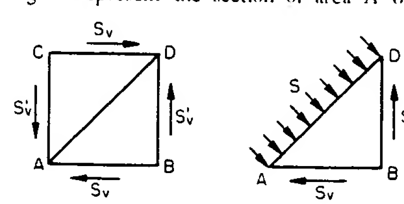

Fig. 6

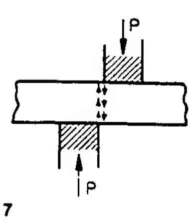

Fig. 7

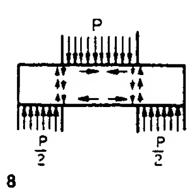

Fig. 8

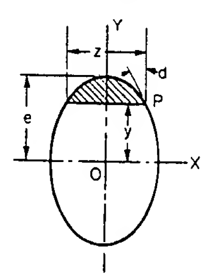

Fig. 9

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MECHANICAL ENGINEERING DESIGN

Fourth Edition

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Use of the equation

$$\tau = \frac{F}{A} \tag{2-13}$$

for a body, say a bolt, in shear assumes a uniform stress distribution too. It is very difficult in practice to obtain a uniform distribution of shear stress; the equation is included because occasions do arise in which this assumption is made.

2-5 ELASTIC STRAIN

When a straight bar is subjected to a tensile load, the bar becomes longer. The amount of stretch, or elongation, is called *strain*. The elongation per unit length of the bar is called *unit strain*. In spite of these definitions, however, it is customary to use the word "strain" to mean "unit strain" and the expression "total strain" to mean total elongation, or deformation, of a member. Using this custom here, the expression for strain is

$$\epsilon = \frac{\delta}{l} \tag{2-14}$$

where δ is the total elongation (total strain) of the bar within the length l.

Shear strain γ is the change in a right angle of a stress element subjected to pure shear.

Elasticity is that property of a material which enables it to regain its original shape and dimensions when the load is removed. Hooke's law states that, within certain limits, the stress in a material is proportional to the strain which produced it. An elastic material does not necessarily obey Hooke's law, since it is possible for some materials to regain their original shape without the limiting condition that stress be proportional to strain. On the other hand, a material which obeys Hooke's law is elastic. For the condition that stress is proportional to strain, we can write

$$\sigma = E\epsilon \tag{2-15}$$

$$\tau = G\gamma \tag{2-16}$$

where E and G are the constants of proportionality. Since the strains are dimensionless numbers, the units of E and G are the same as the units of stress. The constant E is called the *modulus of elasticity*. The constant G is called the *shear modulus of elasticity*, or sometimes, the *modulus of rigidity*. Both E and G, however, are numbers which are indicative of the stiffness or rigidity of the materials. These two constants represent fundamental properties.

By substituting $\sigma = F/A$ and $\epsilon = \delta/l$ into Eq. (2-15) and rearranging, we

obtain the equation for the total deformation of a bar loaded in axial tension or compression.

$$\delta = \frac{Fl}{AE} \tag{a}$$

Experiments demonstrate that when a material is placed in tension, there exists not only an axial strain, but also a lateral strain. Poisson demonstrated that these two strains were proportional to each other within the range of Hooke's law. This constant is expressed as

$$\mu = -\frac{\text{lateral strain}}{\text{axial strain}} \tag{2-17}$$

and is known as *Poisson's ratio*. These same relations apply for compression, except that a lateral expansion takes place instead.

The three elastic constants are related to each other as follows:

$$E = 2G(1 + \mu) \tag{2-18}$$

2-6 STRESS-STRAIN RELATIONS

There are many experimental techniques which can be used to measure strain. Thus, if the relationship between stress and strain is known, the stress state at a point can be calculated after the state of strain has been measured. We define the *principal strains* as the strains in the direction of the principal stresses. It is true that the shear strains are zero, just as the shear stresses are zero, on the faces of an element aligned in the principal directions. From Eq. (2-17) the three principal strains corresponding to a state of uniaxial stress are

$$\epsilon_1 = \frac{\sigma_1}{E} \qquad \epsilon_2 = -\mu\epsilon_1 \qquad \epsilon_3 = -\mu\epsilon_1 \tag{2-19}$$

The minus sign is used to indicate compressive strains. Note that, while the stress state is uniaxial, the strain state is triaxial.

Biaxial Stress

For the case of biaxial stress we give σ_1 and σ_2 prescribed values and let σ_3 be zero. The principal strains can be found from Eq. (2-17) if we imagine each principal stress to be acting separately and then combine the results by super-